5-1-2013

# Influence of Transplanter Modification and Previous Crop on the Production of No-Till Dark Tobacco

William Frazier Penick
*Western Kentucky University*, william.penick@topper.wku.edu

# INFLUENCE OF TRANSPLANTER MODIFICATION AND PREVIOUS CROP ON THE PRODUCTION OF NO-TILL DARK TOBACCO

A Thesis
Presented to
The Faculty of the Department of Agriculture
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
William Frazier Penick

May 2013

INFLUENCE OF TRANSPLANTER MODIFICATION AND PREVIOUS CROP ON THE PRODUCTION OF NO-TILL DARK TOBACCO

Date Recommended 3/23/13

Todd Willian

Dr. Todd Willian, Director of Thesis

Dr. Rebecca Gilfillen

Jack L. Rudolph Jr.

Dr. Jack Rudolph

Dean, Graduate Studies and Research 5-13-13

Date

For Daddy and Granddaddy.
If not for your abilities, guidance, and dedication, I would not be where I am today.

ACKNOWLEDGEMENTS

To my parents, for their love, support, and encouragement to further my education.

To my sister, for countless hours of editing.

To Dr. Willian, Dr. Gilfillen, and Dr. Rudolph for their guidance and insight provided throughout my stint in the agriculture department.

To the U.S. Smokeless Tobacco Company, I send my utmost gratitude for providing me with this opportunity.

TABLE OF CONTENTS

LIST OF FIGURES

INFLUENCE OF TRANSPLANTER MODIFICATION AND PREVIOUS CROP ON THE PRODUCTION OF NO-TILL DARK TOBACCO

William F. Penick May 2013 43 Pages

Directed by: Dr. Todd Willian, Dr. Becky Gilfillen, and Dr. Jack Rudolph

Department of Agriculture Western Kentucky University

Dark tobacco (*Nicotiana tabacum* L.) has historically been produced using conventional tillage practices. Soil is cultivated multiple times throughout a growing season leading to an increased incidence of soil erosion. No-till systems have been growing in popularity with the advent of new technology that has enabled the practice to be performed effectively and efficiently. With the recent expansion of no-till practices throughout the agricultural community, many crops have had success in producing comparable yields while reducing input costs and saving soil resources.

For this experiment, a traditional tobacco transplanter was modified for use in a no-till environment. All modifications were fabricated without using specialty tools and made possible to be removed if desired or necessary. Frame extensions were designed and built to accommodate row cleaners and coulters. Tillage shanks were also added to aid in optimal furrow formation. Double-disc opening shoes replaced the original round point shoes and the curved edges of the rear drive wheels were removed, creating a flat surface to increase soil contact.

Experimental no-till plots in fescue sod and soybean chaff residues were conducted alongside conventional tillage plots at the Western Kentucky University Agricultural Research and Education Complex in summer 2011. Five treatments, one conventionally tilled (Conv) and four no-till, were replicated three times within a

randomized complete block design and used to determine the efficacy of transplanter modifications (consistency of depth, furrow closure, observed plant damage), survival of the transplants, and the amount of residue displacement. The four no-till treatments utilized different combinations including: coulter, row cleaner and shank (CRS), row cleaner and shank (RS), coulter and shank (CS), and shank only (S). These treatments demonstrated the functionality of each combination in comparison to conventional treatments.

No treatment performed equally well in both residue locations. Plots in fescue residue utilizing a combination of coulter, row cleaner, shank (CRS), exhibited the lowest amount of root exposure, highest survival rate, and comparable cured weight when compared to conventionally tilled treatments. In soybean residue plots, the treatment operating with row cleaners and shanks (RS) had equivalent amounts of furrow closure to conventionally tilled plots. Pairing specific modification combinations with previous crop residue can provide furrow closure, transplant survival, and cured yield equivalent to conventionally tilled dark tobacco.

# CHAPTER I

# INTRODUCTION

Over the past 500 years, tobacco (*Nicotiana tabacum* L.) has become one of the highest grossing small-scale production crops in the United States. In 2011, $1.7 billion were accrued in revenue from 131,118 cropped hectares of tobacco (NASS, 2012). The USDA reports that eight recognized types of tobacco are grown for specific products, each with a distinct cultivation and curing process (NASS, 2012). Unlike flue-cured or burley tobacco varieties, known well for their combustible properties, dark tobaccos are typically utilized in the production of cigar filler, chewing tobacco, and snuff.

Climate and soil type determine the type of tobacco produced in the areas of the United States. Soil type directly influences leaf structure, while differentiating factors among climate areas often determine curing capabilities. Of the many differences that exist within production of various types of tobacco, one practice is essential to them all: tillage.

Tillage is an integral part of tobacco production, from the primary and secondary stages of tillage in preparation for transplanting, to the subsequent in-season cultivations for weed control and soil movement. Methods and implements have been developed through centuries of cultivation to improve and expand the efficacy of the practice. Without proper management, however, soil tillage can degrade the foundation upon which tobacco culture is based. Tilling the soil reduces the structure built over time that has been improved by microbial activity and root channels from previous crops. Extensive tillage also leads to soil compaction over time. This in turn negatively affects water movement into and out of the soil over time, ultimately negatively influencing crop production (Lal, 2004).

In a normal growing season, two to four cultivations occur prior to planting in order to prepare the soil and ease transplanting (Pearce, 2012). Post-transplant tillage of tobacco begins the week following transplanting. The churning motion of tillage implements loosens soil around the rooting zone of newly-placed plants to permit outward root growth. Soil is also pushed up around the base of the transplant, providing support to the stalk (Garner, 1951). Subsequent cultivations typically occur every 7-10 days and continue to loosen soil. Row cultivators are widened to accommodate the expanding root system, and adjusted to a more shallow depth to avoid disruption of root growth. The final cultivation, generally three to four weeks after transplanting, is sometimes accompanied with a mid-season addition of nitrogen. Cultivation after this point is likely to mar the extended root system and damage above ground growth if plant height exceeds the clearance range of the cultivation equipment (Garner, 1951).

Dark tobacco is usually grown on heavy silt loam soils to accommodate the dense, thick, high chlorophyll leaf structure (Akehurst, 1981). Due to the extensive cultivation associated with traditional cropping systems, soil erosion is problematic in areas of dark tobacco production (Garner, 1951). Soil particles that conglomerate to create such soils are in majority composed of silt and clay, the smallest particles that form soils. Being of such small size, silt and clay are more easily broken from topsoil by raindrop impact and washed away by rill erosion. Because dark tobacco is grown on a small scale relative to other major crops, some experts would assert that the amount of soil lost would not be an issue of significance. However, dark tobacco is commonly produced on some of the most fertile agricultural soils in order to achieve a high yielding crop (Davis, 1999). Therefore, soil erosion prevention should be of prime importance in areas of dark tobacco production.

Several conservation tillage methods are utilized to reduce soil erosion in cropping systems. No-till cropping is a division of conservation tillage that allows all residual material left from the previous crop to remain on the soil surface. Crop residues serve as natural barriers to water, wind, and other erosive forces. The following crop is planted directly through the crop residues and into the untilled soil. No-till practices preserve the structure of the soil developed over time, allowing infiltration and percolation of water and expansion of root systems through biologic channels and natural soil formations (Lal, 2004). Tillage interrupts these natural occurrences, while creating compacted layers beneath the surface and creating a greater chance of erosion. No-till reduces both the risk of erosion and labor inputs.

The objectives and intentions of this research study were:

(a) to determine the efficacy of various tobacco transplanter modifications.

(b) to observe the amount of residue displaced by each of the modifications.

(c) to determine the survival rate of the transplants as influenced by modifications.

(d) to evaluate which, if any, combination of additional equipment performed more suitably than another.

## CHAPTER II

## LITERATURE REVIEW

### History

The history of tobacco is unclear, often becoming obscure and conflicting. Christopher Columbus observed the native Arawakan tribesmen rolling and smoking long leaves when he first landed in the West Indies in 1492 on a voyage for the Spanish. It was later discovered that *Nicotiana tabacum* was the species being described. Various ancient civilizations throughout South America, Mexico, and the Caribbean islands were noted as growing crops of tobacco for various uses. The first description of the use of chewing tobacco arises from a visit to an island off the coast of Venezuela by Amerigo Vespucci in 1499. Early reports of tobacco being smoked were associated with the Iroquois Indians of Montreal in 1545; André Thévèt noted its being smoked in Brazil in 1558 (Akehurst, 1981).

John Rolfe is credited with growing the first crop of tobacco for export to Europe in 1612 in Jamestown, Virginia. Nine thousand kilograms were shipped across the Atlantic in 1619; that amount grew to 27,216 kilograms over the next four years (Akehurst, 1981). By 1783, tobacco had made its way to the prosperous lands of Kentucky, but was grown on a very small scale. Commercial production of tobacco spread to Logan, Warren, and Christian Counties in 1810. These were soon to become prime dark tobacco production areas. By 1876, the state of Kentucky was second to Virginia in total production in the United States (Garner, 1951).

Curing processes were also carried over with the movement of tobacco. Virginian fire curing methods were discovered and developed to enhance keeping ability when transported, as well as prevent house burn (Garner, 1951). Dark fire curing culture exists today very much as it did in its infancy. Methods vary, but have very few differentiating factors. Accompanying fire curing methods were those that used no heat in the curing process, creating air curing and leading to the development of One Sucker and Green River tobacco markets.

Decline in the production of tobacco in the United States has been recognized since the Tobacco Buyout Legislation in 2004. In 2011, 131,118 hectares of tobacco were harvested in the United States (NASS, 2012); Kentucky alone produced 30,960 hectares, the second highest in the country. Of this figure, 5,500 hectares were dark tobacco, both air- and fire-cured (NASS, 2012).

**Taxonomy**

As a member of the Solanaceae Family, tobacco is associated with 1800-2500 plant species, including potatoes, tomatoes, and peppers. Tobacco is more often associated with the crops with which it is grown in rotation: corn, wheat, and soybeans (Garner, 1951). Jean Nicot, an Ambassador to Portugal, is credited with the introduction of tobacco (*Nicotiana rustica*) to the royal courts of France in 1560, though French monk André Thévèt made an unsuccessful attempt to introduce a similar species (*N. tabacum*) to the region in 1556 (Garner, 1951). In 1753, Linnaeus established the genus *Nicotiana*, named for Nicot, to include two main production species *Nicotiana tabacum* and *Nicotiana rustica*. Today in the United States, only *N. tabacum* is grown commercially (Tso, 1972).

**Production**

Unlike many other field crops, tobacco is produced solely for its leaves; no other parts of the plant are marketed.  It produces a leaf area rivaled by few other cultivated crops: most individual leaves grow to an average of 0.09-.14 $m^2$ in area.  Based upon this amount of leaf area, a total of 2.3 $m^2$ can be produced by a single plant (Tso, 1972).  The expansive leaves of the dark tobacco plant are primarily used in smokeless tobacco products such as chew and snuff, but are widely used as pipe tobacco and cigar wrappers.

One gram of tobacco seed consists of roughly 10,000 seeds; making direct seeding of the crop unfeasible (Tso, 1972).  Transplanting young plants, therefore, is the most efficient method for large-scale tobacco plant production systems.  Traditionally, transplants were prepared in plant beds, often located along the edge of a wooded area. The forest edge habitat provided soils containing high amounts of organic matter and a loose top layer structure that would not injure the root system when pulled for transplanting.  Hydroponic plant production systems now greatly outnumber the traditional field beds.  "Float bed" plants are grown in trays with individualized cells, making transplant production a more modern and efficient process.  Transplants produced using this method have shown a reduction in the amount of transplant shock upon placement in the field (Davis, 1999).

**Tillage Practices in Tobacco Production**

Tillage has been a primary part of tobacco production since its establishment as a cultivated crop.  Tillage is broadly defined as the movement of soil by mechanical means for the purpose of soil aeration, weed control, and incorporation of organic matter (Lal, 2004). Tillage serves three main purposes in tobacco production: field preparation prior to transplanting, in-season cultivation for weed control, and to loosen and push up soil around plants.

As with other crops, tillage in tobacco has a specific purpose. Churning the soil opens layers contacted by tillage implements, opening the soil to increase aeration, water infiltration, and porosity. These are three beneficial effects for tobacco during early stages of growth. Soil is also pushed around the plant, adding more support to the stalk. Tillage also compacts the soil beneath the plowed layer of soil, affecting aeration and water infiltration as a whole (Lal, 2004).

Crusts form at the surface of soil as a result of a rainfall event. These crusts are broken up through cultivation, reverting the soil to its previously loosened state to aerate soil and increase water infiltration (Hillel, 1982).

Tillage operations carried out in early spring have a great effect on soil temperature. Tilled soil has exhibited higher surface temperatures than no-till soil counterparts (Lal, 2004). This can impact transplant growth, root development, as well as soil fauna (Hillel, 1982).

Though water infiltration rates of the soil are increased by tillage, once the soil saturation point is reached, higher amounts of erosion will occur. This results in high amounts of precipitation runoff containing soil particles. Pesticides and fertilizers attach to soil particles, leading to pollution of the runoff. No-till cropping systems leave behind crop residues after harvest; these residues consist of both vegetative plant material and root matter. These materials decrease particulate runoff, and the rate of runoff slows more by the residue being present (Lal, 2004). Leaving residual cover from previous crops in place also contributes to soil organic matter levels, which aids in nutrient and water holding ability as well as the increased adsorption of soil applied pesticides.

Very little evidence supporting the benefits of tillage on the growth of tobacco is in existence (Garner, 1951). An increase in growth in recently transplanted tobacco can be demonstrated by cultivation in some instances where a high amount of clay content is present in the soil (Akehurst, 1981). In a weed-free environment, flue-cured tobacco received benefits when tilled (Hawks, 1970).

**No-Till Production Systems in Agriculture**

The premise of no-till crop production was conceived long ago. In primitive agriculture systems, a stick or peg was used to create a void in soil, into which to insert a seed, which was covered and allowed to grow. Not long after this, a transition to scratching the soil surface then seeding was devised, thus creating the first forms of tillage. With the increase in knowledge and skill of people across the globe, tillage technology rapidly expanded into current practices (Huggins, 2008).

Before the advent of effective herbicidal technology, no-till agriculture remained nothing more than a distant dream of many producers. Since the 1960's, no-till has been implemented into many agricultural cropping systems, many of them being row crop utilizations (Huggins, 2008). Planting equipment, very similar to that of conventional agriculture, requires some modification, though today most implements are equipped to manage no-till terrain. The high costs of these implements can be offset by the lessened need for disks and plows, the tillage tools once synonymous with production agriculture.

No-till practices improve many aspects of soil health simply by doing essentially nothing (Lal, 2004). By improving soil aggregation with no-till, the porosity of soil is increased, which in turn results in higher amounts of aeration and water infiltration. Crop residues shield the soil from direct raindrop impact decreasing the amount of runoff created and increasing the soil's ability to take in water (Lal, 2004). By eliminating tillage, channels created by microorganisms and previous root growth remain, allowing water infiltration and aeration to remain constant or increase in time.

Evidence from several studies has shown that tobacco of any type grown in a no-till environment will be slower to grow within the first few weeks after transplanting. Differences in soil temperature at transplanting and the weeks following is the primary contributing factor, as postulated by Chappell (1977). Soil temperature has a distinct effect on water movement and availability, evaporation, and soil aeration (Lal, 2004). Results of lower survival rates of no-till burley in comparison to conventional (Morrison, 1973) were reinforced by a burley study conducted in 1989, in which no-till treatments were found to have just 1% less surviving transplants than conventional counterparts to exhibit higher rates of midseason growth (Phillips, 1989).

No-till cropping systems boast many economic advantages including reduced fuel consumption, lower machinery costs, and lower labor inputs, but soil-saving aspects are also an important feature. Due to lack of soil cover and low plant population rates, tobacco soils are more susceptible to erosion than other commercially grown crops in the United States (Wood, 1986). In a 1986 study, no-till plots had 20-90 times less erosion than conventional plots, depending upon slope and soil type (Wood, 1986). More recently, Yoder (2005) reported reductions in erosion more definitively as 92%.

As with any crop in production agriculture, the ultimate determining factor of adopting a new practice is yield. Can a comparable or exceeding yield be acquired by a practice that causes the producer to eliminate an integral part of traditional tobacco culture? It is most often noted that yields of any type of no-till tobacco are not significantly different from conventionally grown counterparts (Hoyt, 2000), (Roach, 1981), (Wood, 1986). High and medium amounts of residue present throughout the growing season have the ability to suppress yields in comparison to low amounts, a problem rectified by proper timing of cover crop burndown prior to transplant (Ellis, 2001).

**Requirements for a Successful No-Till Transplanter**

Through many years of experimentation, researchers have modified tobacco and vegetable transplanters to meet the necessary needs. Morrison (1973) was the first of these, converting a one-row conventional transplanter to operate in a no-till environment.

Morse (1993) laid out the necessary requirements for the creation of a successful transplanter: a) adequate structure and implements that can successfully transplant under the most challenging conditions, b) have the ability to place transplants in areas with high amounts of residue without disturbing the soil more than necessary, c) create a furrow of tilled soil for proper plant placement, and d) have the ability to cover transplants with soil loosened by preceding tillage tools. These categories were the basis for the creation of an SST-T transplanter in 1993 that was able to penetrate the densest of material left on the soil surface (Morse, 1993). In a study released by the University of Kentucky, a one-row carousel transplanter was modified and utilized in the production of burley transplants that showed promising results in the field (Pearce, 2003).

As study and inquiry of the subject expand in the field of no-till tobacco production, research will continue. Adoption by producers may be the most difficult challenge to overcome. When producing such a high yielding, low acreage crop that includes more manual labor than many other commercial crops grown in tobacco producing areas, producers are eager to sustain yields as much as possible without increasing acreage. Further research on the subject to improve yield and in-season weed control would be beneficial to both the quality of the soil and to producers.

# CHAPTER III

# MATERIALS AND METHODS

In July 2010, a Mechanical Transplanter™ brand two-row rear drive tobacco and vegetable transplanter (Figure 1) was acquired for modification. All modifications completed for this project were carried out in a standard farm shop without using specialized equipment and were designed to bolt on for ease of assembly, replacement, or desired removal.

A typical transplanter consists of a furrow-opening shoe, watering mechanism, setting fingers or a carousel mechanism, and a contact drive system. A transplanter intended for no-till use includes additions of implements to create a furrow in untilled soil, place the transplant, and properly cover the root ball leaving the soil relatively undisturbed.

The transplanter was disassembled, modified, repainted, and reassembled (Figure 2). All deteriorated parts including drive chains, pocket chains, finger grips, finger springs, water trips, and water valve mechanisms were replaced with new parts to ensure smooth machine operation.


**Figure 1.** Transplanter prior to modification.

**Figure 2.** Transplanter after modification.

## Frame Extensions

In order for the desired modifications to be made, it was necessary to extend the length of the implement. Two frame extensions (Figure 3) were constructed using 5” x 7” x 0.1875” (12.7 cm x 17.8 cm x 0.47625 cm) steel square tubing to a final size of 24” x 17” (61 cm x 43 cm). Sections cut to lengths of 17” x 10” (43 cm and 25.4 cm) were welded together, with the 17” (43 cm) pieces standing vertically and the 10” (25.4 cm) sections horizontally. For added strength, 0.1875” (0.47625 cm) plates measuring 3” x 7” (7.6 cm x 17.8 cm) were welded over each butt weld. Four 1” (2.54 cm) diameter holes were cut into the exposed faces of the 17” (43 cm) sections, 1.75” (4.5 cm) from the top edge and 4.5” (11.4 cm) apart, to allow for normal mounting to the frame of the transplanter. One quarter inch (0.635 cm) plate measuring 4” x 17” (10.2 cm x 43 cm) was used to again add strength. Holes were extruded to match those in each end of the frame extension pieces. These plates were placed inside the frame extension pieces and bolted in using 1” x 3” (2.54 cm x 7.6 cm) size hardware. With the additional length of the transplanter, adequate space was available to the mount row cleaner units and hydraulically raise and lower the transplanter.

## Row Cleaners Mounts

In order to mount each row cleaner unit, mounts were fabricated (Figure 4). Two plates measuring 4” x 8” (10.2 cm x 20.3 cm) were cut from 0.375” (0.95 cm) steel stock and two 0.625” (1.6 cm) diameter holes spaced 4” (10.2 cm) apart. Coulter brackets (AA32693) from a John Deere™ 7000 series planter were repurposed for each row cleaner mount. Reversed from the normal position on a planter unit, each coulter mount

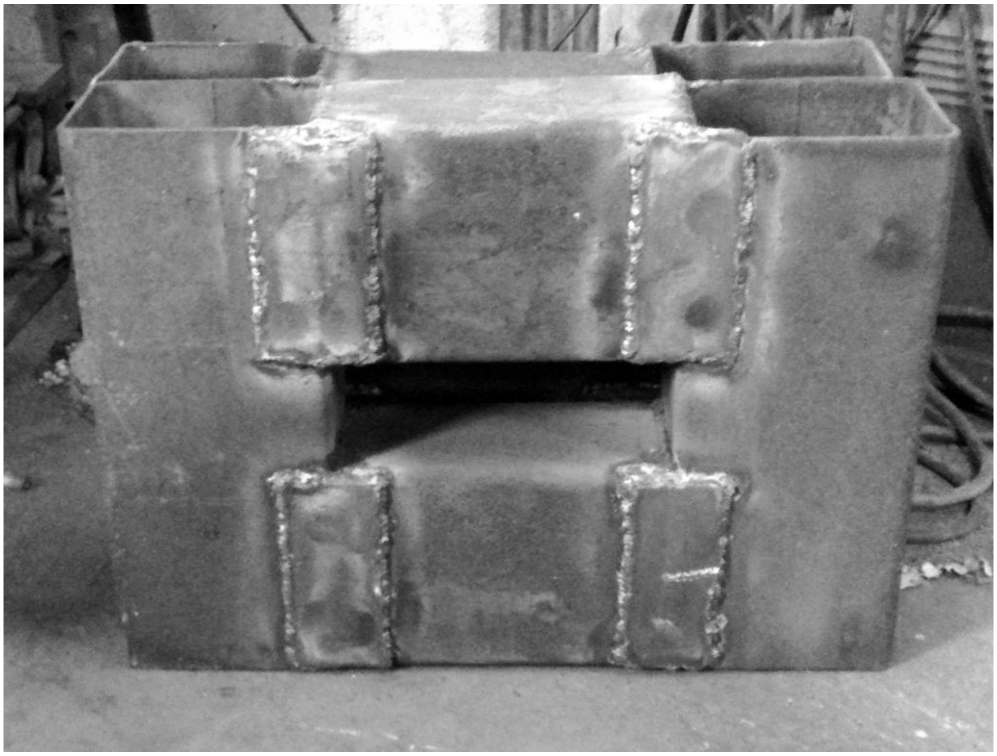

**Figure 3.** Frame extensions.

**Figure 4.** Row cleaner mounts with Martin™ C125R row cleaners and coulter.

was centered and leveled onto the previously cut base plate and welded securely. Once completed, one mount was affixed to the base of each unit bracket beneath the toolbar using the factory 0.75” (1.9 cm) v-bend u-bolt. After placement, Martin™ C125R row cleaners equipped with Side Treader Wheels and Kinze™ no-till coulter mounts with bubble style discs were bolted on using 0.5” x 2.5” (1.27 cm x 6.35 cm) hardware.

**Shank Mounts**

Limited space for a shank mount (Figure 5) led to the need for a piece that would fit between the double-disc opener and the toolbar mounting point of the transplanter unit. The parallel frame rails of each unit are composed of 2.5” (6.35 cm) tall 0.375” (0.96 cm) thick flat steel spaced 3.625” (9.2 cm) apart. The mount was designed to rest atop and fit between the frame rails. Two 5” x 7” x 0.5” (12.7 cm x 17.8 cm x 1.27 cm) steel plates were used to fabricate the top and bottom portions of the mount. Holes measuring 1.5” x 4” (3.8 cm x 10.2 cm) were cut into each plate. One plate was welded and became the top piece, the second acted as a bolting plate for installation. Two 15” (38.1 cm) lengths of 3.625” (9.2 cm) wide 0.25” (0.64 cm) thick steel plates were cut. Four 0.5625” (1.4 cm) holes spaced 1.5” (3.81 cm) apart were drilled into each plate beginning 1” (2.54 cm) from the end. The pieces were then placed into the 2” x 4” (5.1 cm x 10.2 cm) hole cut into one 5” x 7” (12.7 cm x 17.8 cm) plate, and welded to each side. A 3” x 3.5” x 0.75” (7.6 cm x 8.9 cm x 1.9 cm) plate was then welded between the two upright 0.25” (0.64 cm) steel plates. A 0.25” (0.64 cm) cap measuring 3.5” x 4.75” (8.9 cm x 12.1 cm) was welded over the exposed top end. The mount was then placed on the frame rails of the transplanter unit and centered. The second 5” x 7” (12.7 cm x 17.8

cm) plate was designed to slide on from the underside and bolted to secure the mount in place. Nichols™ N5P8 anhydrous knives (Figure 6) were used as tillage shanks. The fertilizer tubes, unnecessary for this application, were removed to allow for the knife to properly fit into the mount. These knives are readily available and easily replaced or exchanged for another type of tillage shank if necessary.

The wide gap in the mount allows for a wider tillage shank to be implemented if desired. For this operation washers were placed between the anhydrous knife and the sides of the mount to allow the knife to be centered in the row.

### Double-Disc Openers

Used in place of the original shoes, Mechanical Transplanter™ double-disc openers (1000 DD SCMP) were mounted to cut into the trench created by the cutting coulter and anhydrous knives to ease the formation of the furrow and create a suitable environment for transplant placement.

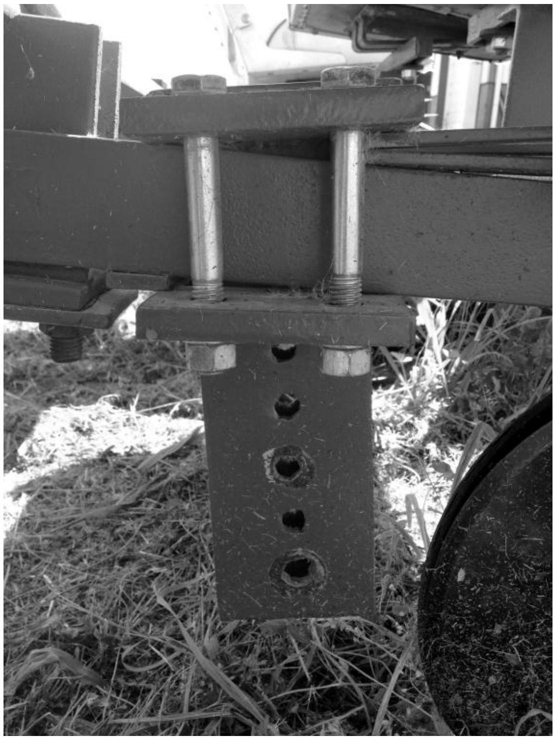

**Figure 5.** Shank mount.

**Figure 6.** Nichols™ N5P8 anhydrous knife used as tillage shank.

## Closing Wheels

The original closing wheels (Figure 7) were made to direct and compact loose soil in a conventional tillage system. In a no-till system, less loose soil is present, increasing the need for down pressure to close the slit created in the soil. To do this, the curved edge of each wheel was marked and removed using an oxy-acetylene cutting torch creating a flat surface (Figure 7) to contact the soil and close the furrow. After grinding and rounding off sharp edges, the wheels were placed back on the transplanter.

## Weight Brackets

At the end of each unit, weight brackets (Figure 8) were constructed to accommodate typical weights that would be used on a tractor for added down pressure. Two sections of angled steel 0.5” x 3” x 4” (1.27 cm x 7.6 cm x 10.2 cm), were cut to 3.5” (8.9 cm) widths. A 2” (5.1 cm) wide 1” (2.54 cm) deep notch was cut into the top of the bracket for secure weight placement. More weight enables the rear drive wheels to contact the soil properly and for improved operation.

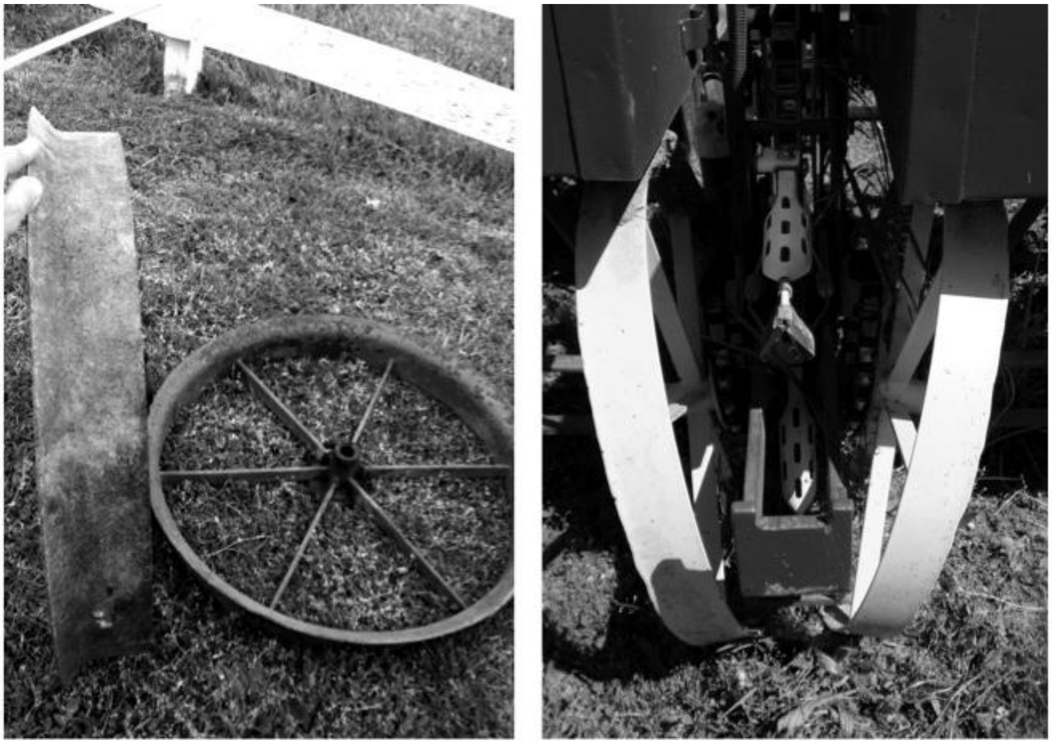

**Figure 7.** Closing wheels before and after edge removal.

**Figure 8.** Weight brackets.

## Field Preparation

Two locations were selected for evaluation at the Agricultural Research and Education Complex of Western Kentucky University, Bowling Green, Kentucky. The two sites, a fescue sod (F) on a Crider silt loam (7.8 pH, 2.7% OM) and soybean chaff (S) on a Lawrence silt loam (6.9 pH, 2.8% OM), were selected to analyze the performance of transplanter modification on growth and development of conventionally grown and no-till tobacco. A randomized complete block design replicated four no-till treatments and one conventionally tilled treatment three times in each residue. Each no-till treatment utilized a separate combination of implements for comparison. Four rows of hydroponic dark tobacco (cv. Narrow Leaf Madole) spaced 1m apart were transplanted into each plot measuring 10 m x 4.6 m.

## Pesticide and Fertilizer Applications

Each field received 1.12 kg ai/ha glyphosate @ 112 L/ha as a burndown two weeks prior to transplanting followed by a mixture of sulfentrazone (0.336 kg ai/ha) and clomazone (0.448 kg ai/ha) at a rate of 187 L/ha, one week before transplanting. Within each residue replication, a control treatment was conventionally tilled to a depth of 15cm using a P.T.O.-driven roto-tiller.

Plots within each residue received identical amounts of prescribed additions of nitrogen, phosphorus, and potassium on June 13. Fescue sod plots received a broadcast of 280 kg N per hectare and 56 kg P. No additions of K or lime were necessary. Soybean chaff plots received 280 kg N, 75 kg P, and 304 kg K. No lime additions were necessary. No midseason additions of side dressed N were applied to any of the treatments.

Four weeks after transplant, sethoxydim (.32 kg ai/ha) and crop oil concentrate at 1% v/v were applied at 224 L/ha to all plots for midseason grass control. Spot spray applications of sethoxydim were applied as needed.

**Residue Measurement**

Residue cover was measured using the line transect method (Wollenhaupt, 1993). Three 3m diagonal lines were painted onto the residue in each treatment. Using a measuring tape, residue present at a foot marker represented 10% cover. Data was collected at each line in both residues before and after transplanting.

**Transplanting**

Transplanting in the fescue residue occurred June 8, 2011. The first treatments transplanted were those using all added components; coulter, row cleaner, and shank (CRS). Combinations were reduced in succession, coulter and shank (CS), row cleaner and shank (RS), and shank alone (S), as each treatment was transplanted. The anhydrous knife shank was set at the lowest position for every treatment. Each combination was paired with a double-disc opener. Conventional plots were transplanted using only the remaining double-disc opener. Transplanting in the soybean residue took place June 10, 2011 using the same succession of equipment combinations.

## Stand Counts

On the day of transplanting, observations were made within each treatment to determine the effectiveness (furrow closure and evidence of root exposure) of transplant placement and cover in each residue. Stand counts were taken at the same time. An exposed root ball was designated as an uncovered plant. Counts of surviving plants were taken 14 days after transplant (DAT).

## Topping and Suckering

Topping and suckering of the plots took place 60 DAT. Plants were topped to 16 leaves in all treatments. A 6% solution of maleic hydrazide (4% - 40 ml/L) and butralin (2% - 20 m /L) was used for sucker control. 60 milliliters of the mixture was applied to each plant using a tip and pour measurement bottle.

## Harvest and Curing

Plants were harvested in fescue residue plots 100 DAT and 107 DAT in soybean residue plots. One replication was harvested per day. To eliminate a border effect, only the center two rows of each treatment were harvested and the end plants of the center rows were excluded from data collection. Harvested plants were stripped of their leaves in order to record separate leaf and stalk green weight. Leaves were then banded into hands of 6 leaves, transported, and hung in an air curing structure in Allensville, KY for a period of 80 days. Once cured and in order, leaves were baled and transported back to the Agricultural Research and Education Complex of Western Kentucky, Bowling Green, Kentucky where plot weights were recorded.

CHAPTER IV

RESULTS AND DISCUSSION

**Transplanter Efficacy in Fescue Sod Residue**

The number of plants per plot varied among treatment in the fescue sod residue (Figure 9). F-CRS and F-CS plots had a significantly higher number of plants than F-RS and F-S plots ($P \leq 0.05$). Conventional plots shared significance with F-CRS, F-CS, and F-S, but contained a greater number of plants than F-RS.

Conventionally tilled and F-CRS plots had the lowest number of plants exhibiting root exposure (Figure 10) ($P \leq 0.05$). F-CRS plots showed no significant difference in root exposure from conventionally tilled plots. F-RS and F-S plots showed no difference from F-CRS plots, but exhibited more root exposure than conventionally tilled plots.

Treatment influenced survival rate as F-CRS and F-CS had equivalent numbers of surviving plants as F-Conv plots (Figure 11) ($P \leq 0.05$). F-RS and F-S treatments had significantly lower transplant survival than F-Conv and F-CRS.

**Residue Displacement in Fescue Sod Residue**

Residue displacement was another parameter used to determine efficacy and consistency. Prior to transplanting, there were no statistical differences in the amount of residue present in any no-till plot in the fescue sod residue (Figure 12) ($P \leq 0.05$). After transplant, F-CRS treatments displaced significantly higher amounts of residue than F-S treatments (Figure 12). There were no differences between F-CRS, F-CS, and F-RS treatments in the amount of residue displaced.

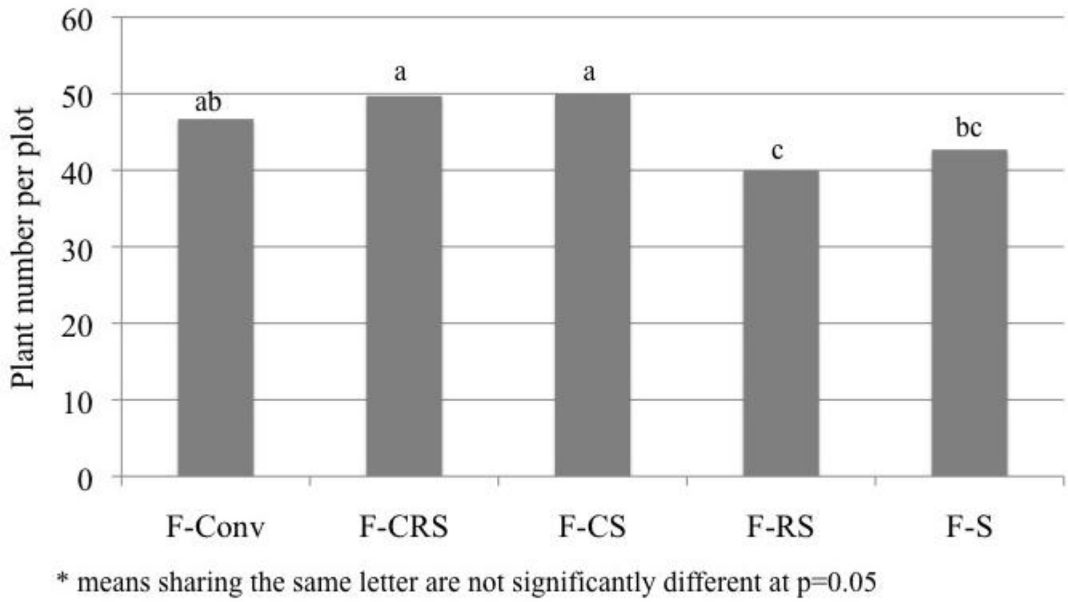


**Figure 9.** Initial plant number per plot on day of transplant in fescue sod residue.

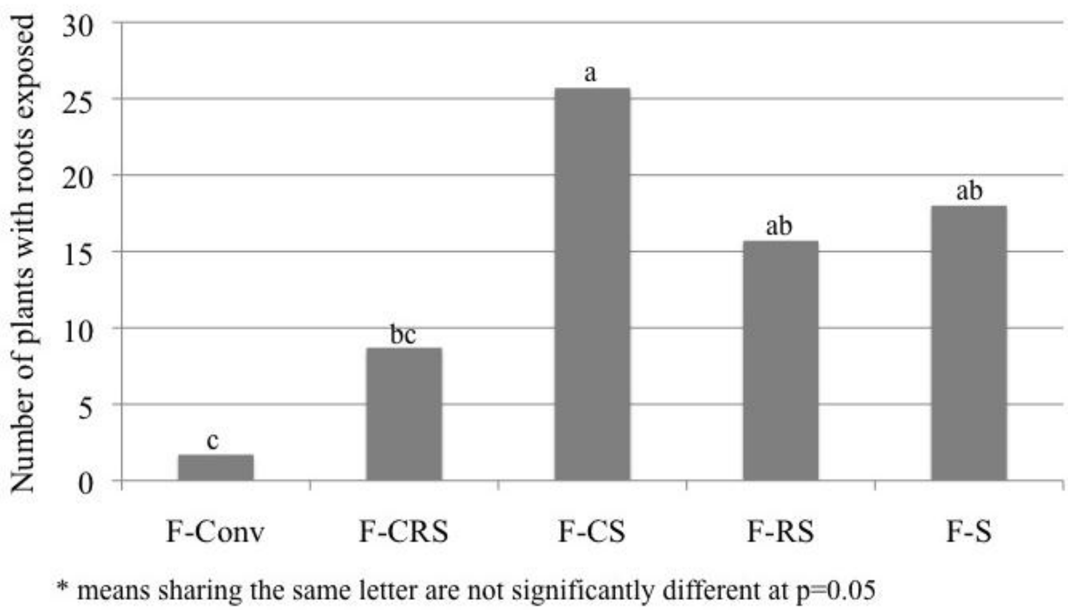


**Figure 10.** Root exposure on day of transplant in fescue sod residue.

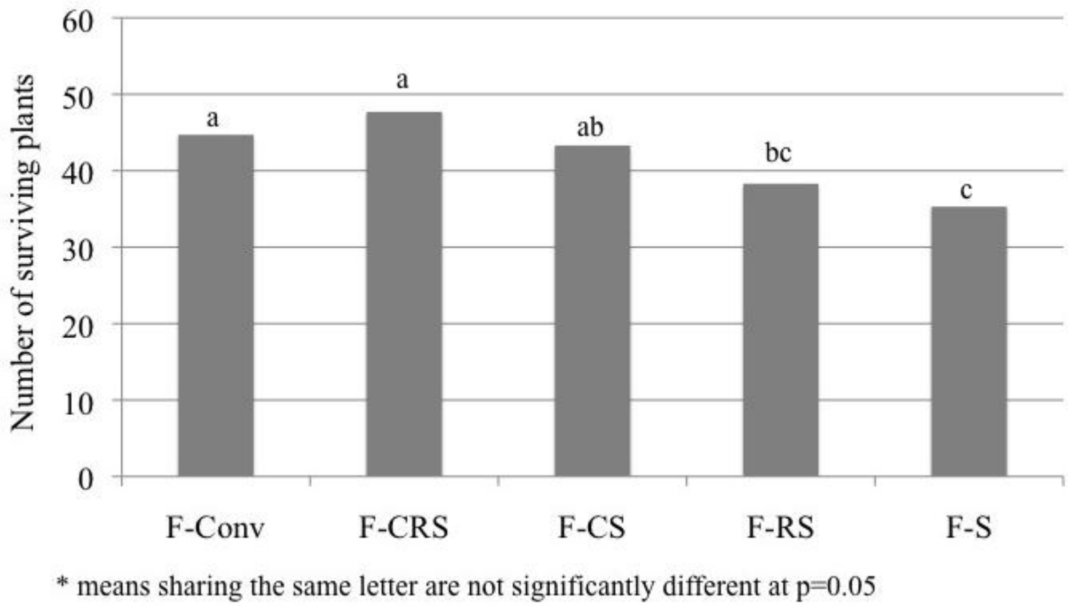


**Figure 11.** Surviving plants two weeks after transplant in fescue sod residue.

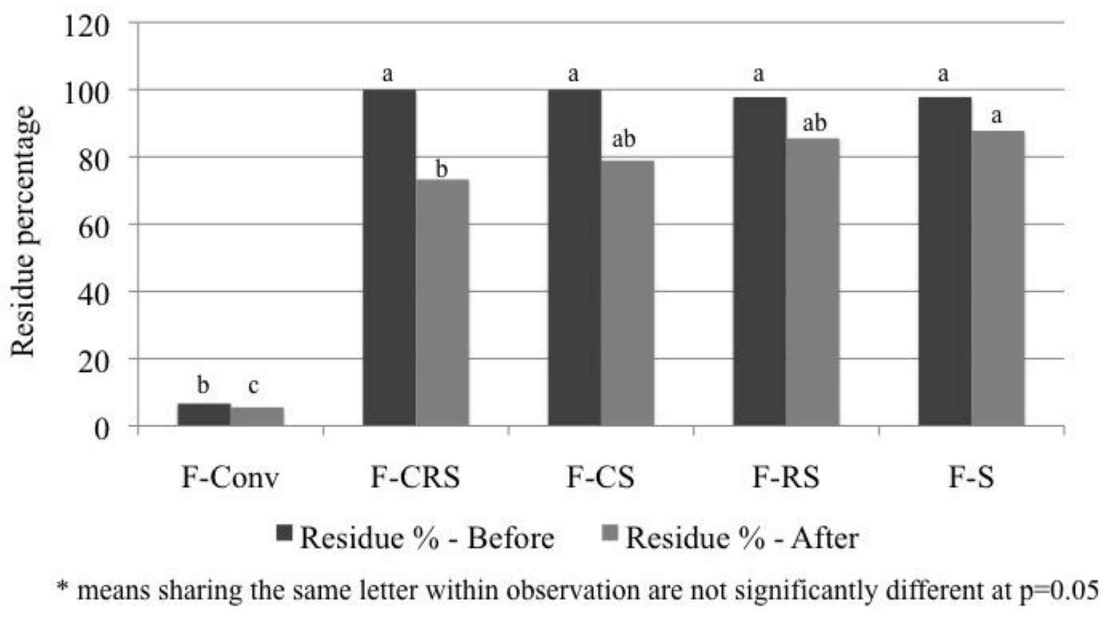


**Figure 12.** Residue percentage before and after transplanting in fescue sod residue.

**Fescue Sod Harvest Data**

Though numerical differences occurred, there were no significant differences in the number of plants harvested from any plot in the fescue sod residue (Figure 13) ($P \leq 0.05$). Fresh green leaf weight was higher in F-Conv and F-CRS plots, than in F-CS, F-RS, and F-S plots (Figure 14) ($P \leq 0.05$). There were no differences between F-CS, F-RS, and F-S plots. F-Conv and F-CRS also outweighed F-CS, F-RS, and F-S plots in fresh green weight (Figure 15) ($P \leq 0.05$) and fresh green stalk weight (Figure 16) ($P \leq 0.05$).

Cured weight per plot differed among treatments in the fescue sod residue (Figure 17) ($P \leq 0.05$). F-CS, F-RS, and F-S treatments had significantly lower cured weight than F-CRS and F-Conv plots. No statistical difference was found between F-CRS and F-Conv. On a per plant basis, yield did not differ among fescue sod residue treatments (Figure 18) ($P \leq 0.05$).

Efficacy of the combination of all three components, coulter, row cleaner, and shank in F-CRS treatments proved best in this situation due to the amount and type of residue present and in need of displacement. The combined effect of these implements produced treatments statistically equal survivability and cured weight to conventionally tilled treatments.

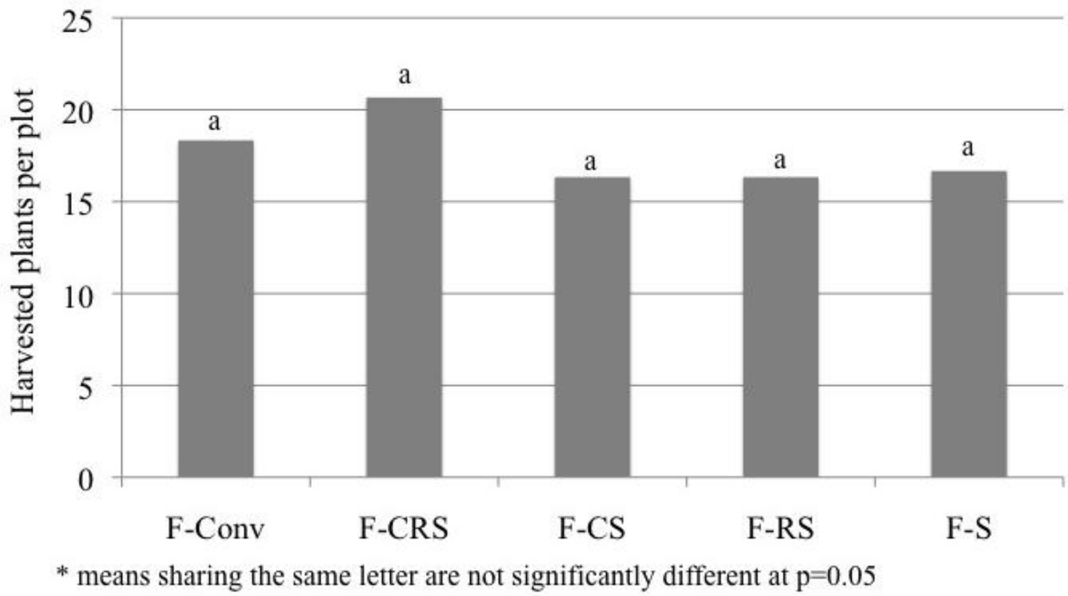


**Figure 13.** Number of plants harvested per plot in fescue sod residue.

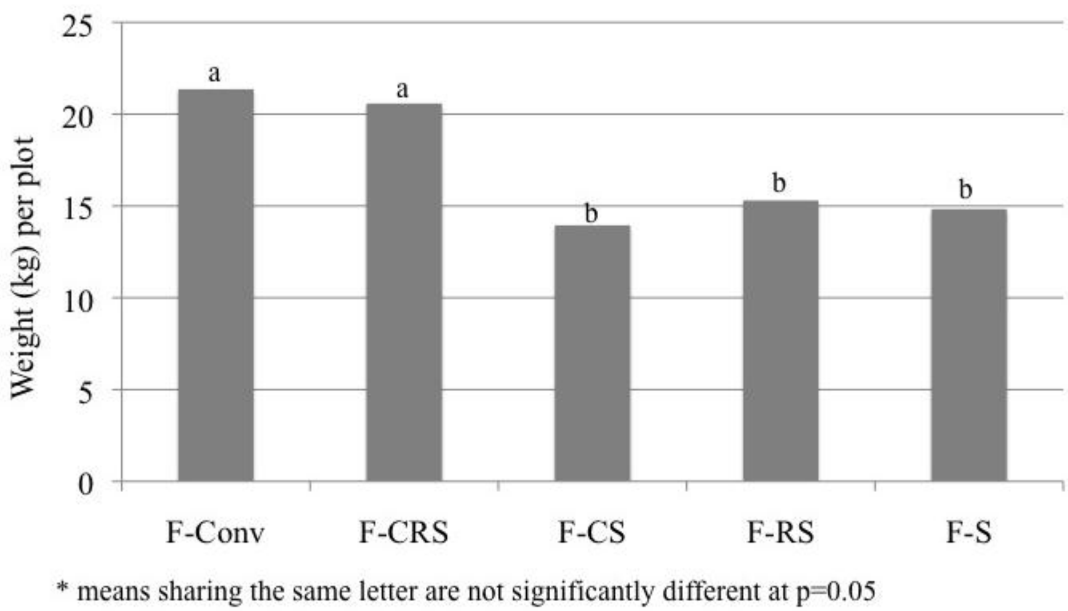


**Figure 14.** Fresh green leaf weight in fescue sod residue.

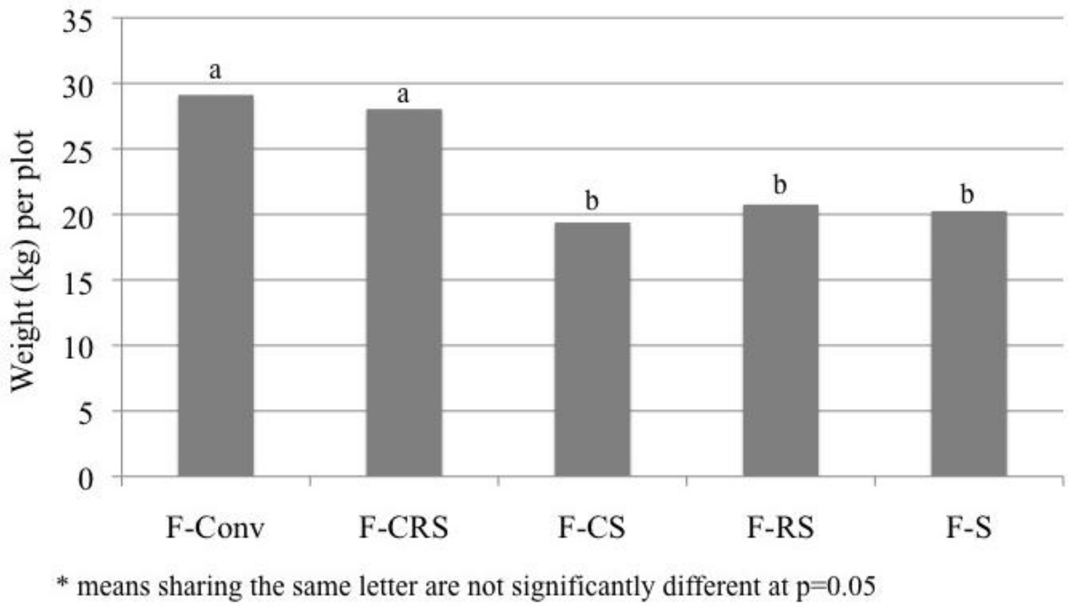


**Figure 15.** Total plant fresh green weight in fescue sod residue.

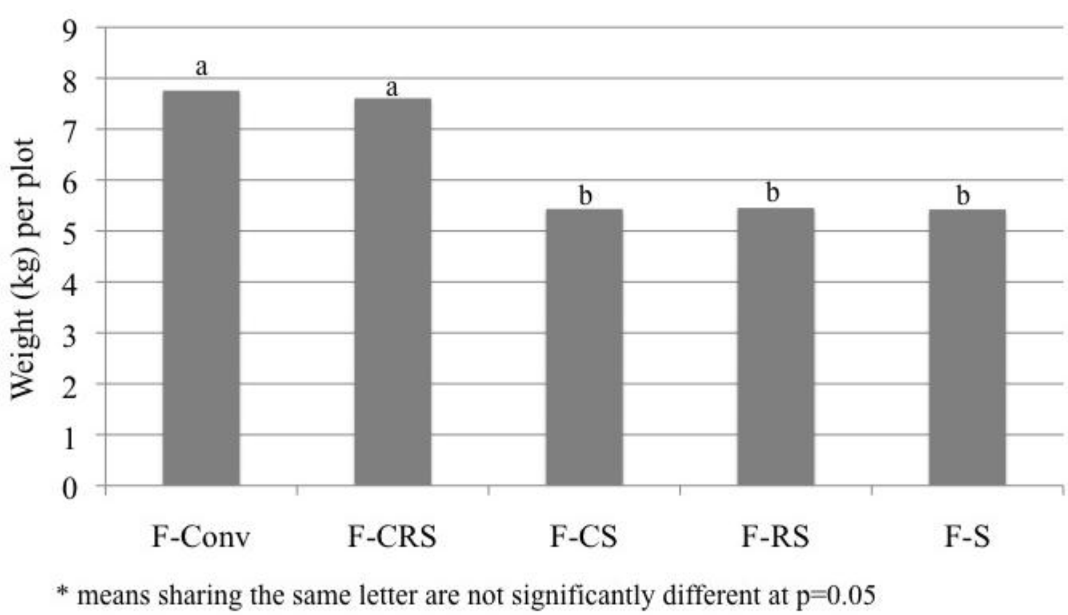


**Figure 16.** Fresh green stalk weight in fescue sod residue.

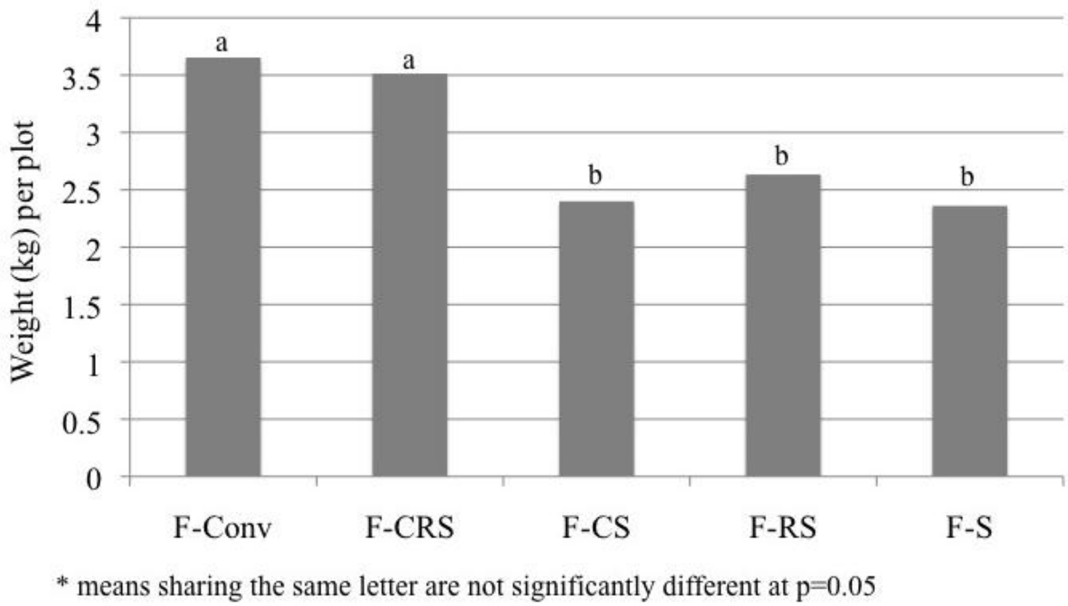


**Figure 17.** Cured weight per plot in fescue sod residue.

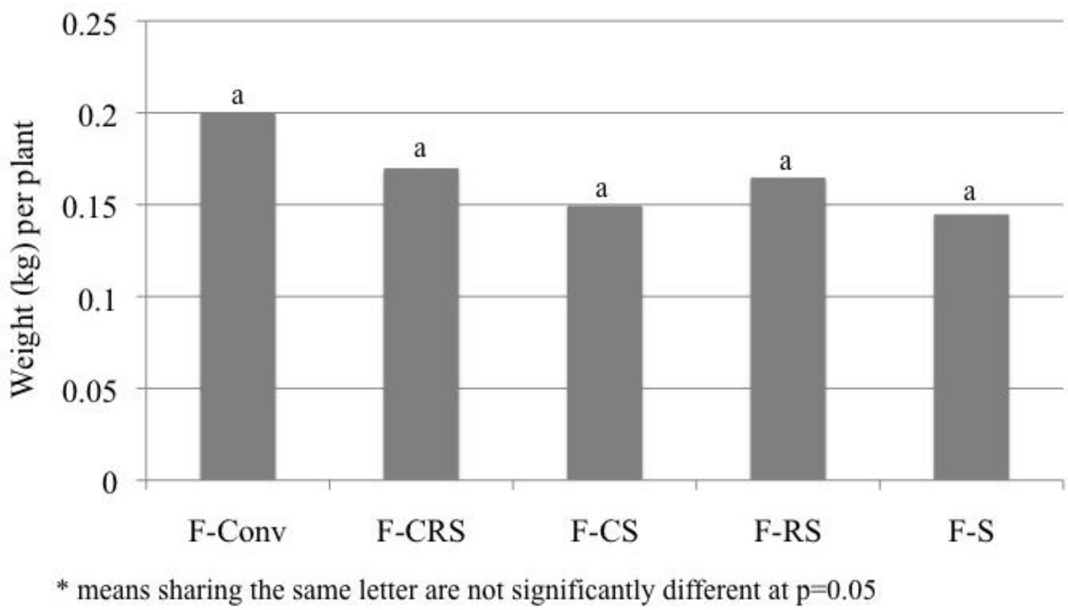


**Figure 18.** Cured weight per plant in fescue sod residue.

### Transplanter Efficacy in Soybean Chaff

The number of plants transplanted into S-CRS and S-CS was higher than S-RS (Figure 19) ($P \leq 0.05$), but not significantly different than S-Conv or S-S plots. S-Conv and S-S plots had a higher number of transplants, but were not significantly higher than S-RS plots.

The amount of root exposure was influenced by treatment. S-RS and S-S plots showed no difference from S-Conv plots (Figure 20) ($P \leq 0.05$). S-CRS resulted in higher rates of root exposure than S-Conv, S-RS, and S-S plots, but did not differ from S-CS.

Treatment had no effect on survival rate (Figure 21) ($P \leq 0.05$), though S-CRS transplant survival was numerically lower than all other treatments.

### Residue Displacement in Soybean Chaff

The percentage of residue prior to transplanting was not significantly different in any no-till treatment in the soybean chaff. No differences in residue displacement were found among any no-till treatments in the soybean chaff residue, however, S-RS treatments displaced the largest numerical amount of residue (Figure 22) ($P \leq 0.05$).

### Soybean Chaff Harvest Data

At harvest, there were no differences in the number of plants taken for experimental data (Figure 23) ($P \leq 0.05$).

No differences in fresh green leaf weight (Figure 24) ($P \leq 0.05$), fresh green total weight (Figure 25) ($P \leq 0.05$), or fresh green stalk weight (Figure 26) ($P \leq 0.05$) were found.

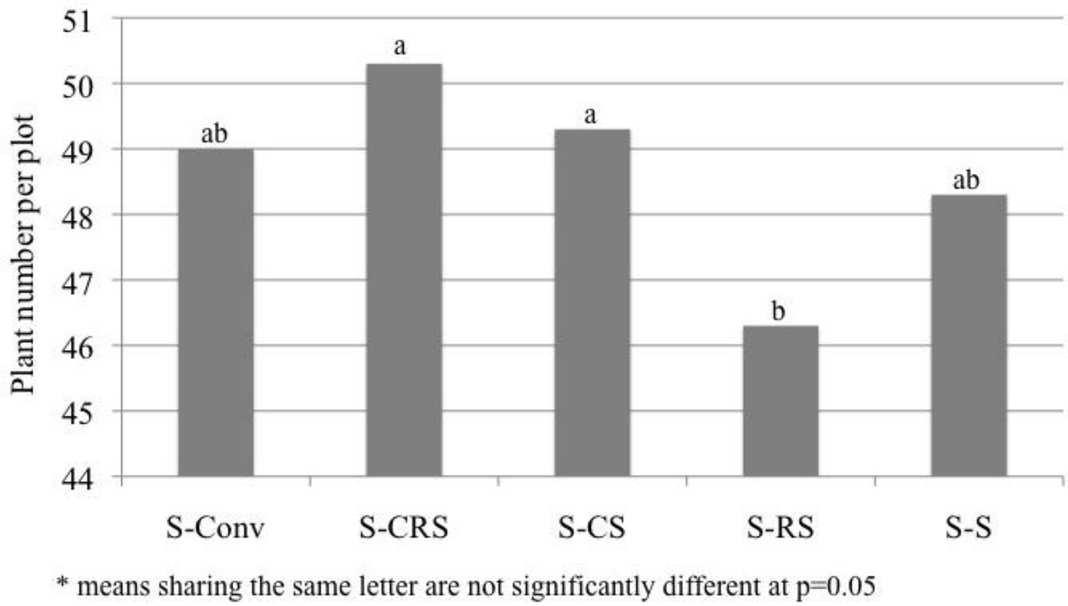


**Figure 19.** Initial plant number per plot on day of transplant in soybean chaff residue.

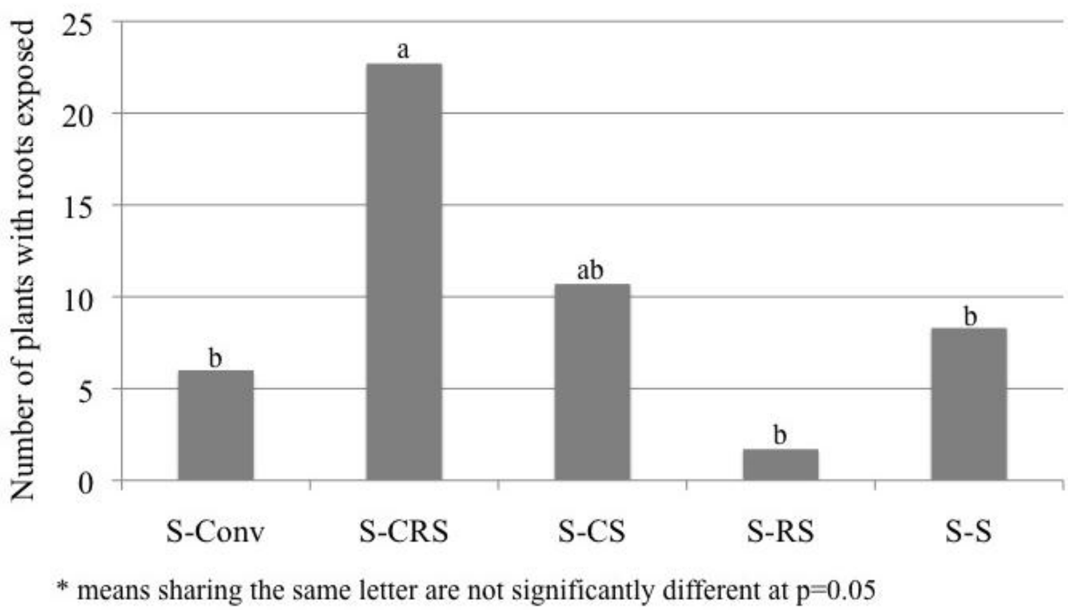


**Figure 20.** Root exposure on day of transplant in soybean chaff residue.

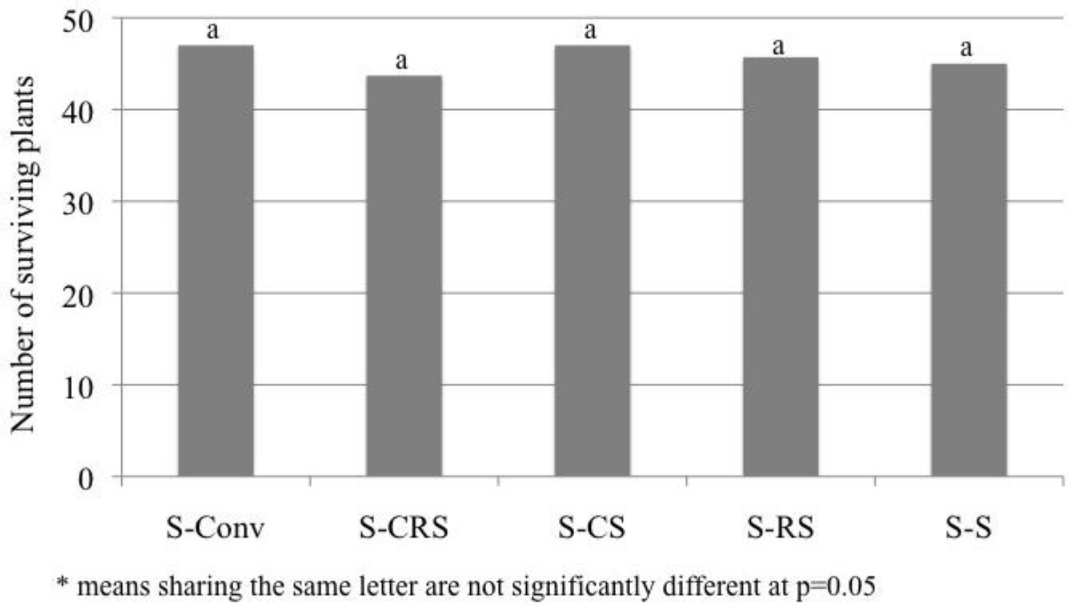


**Figure 21.** Surviving plants two weeks after transplant in soybean chaff residue.

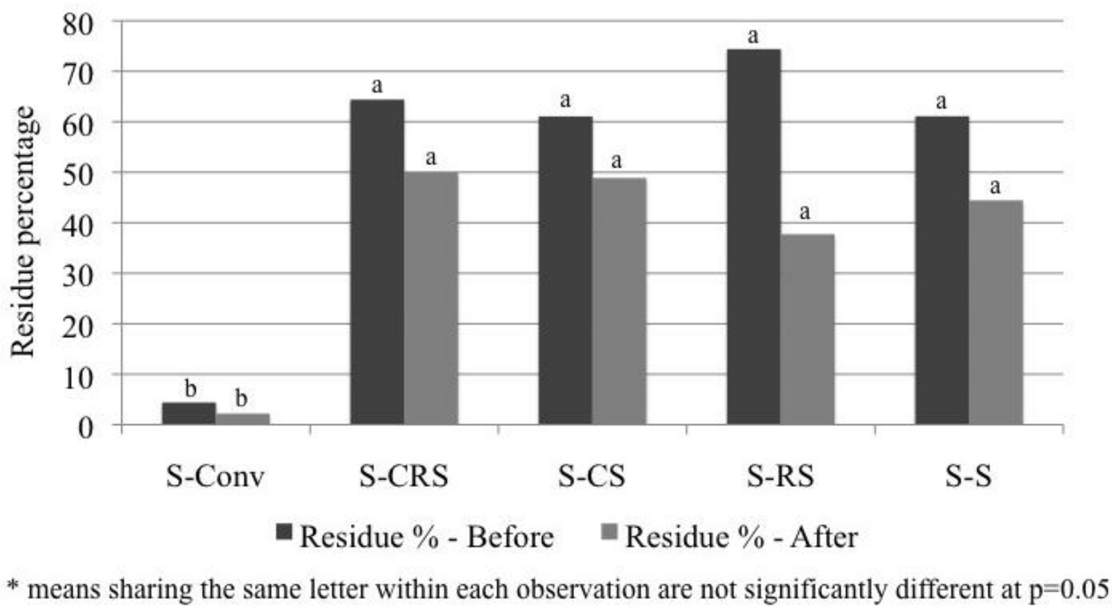


**Figure 22.** Residue percentage before and after transplant in soybean chaff residue.

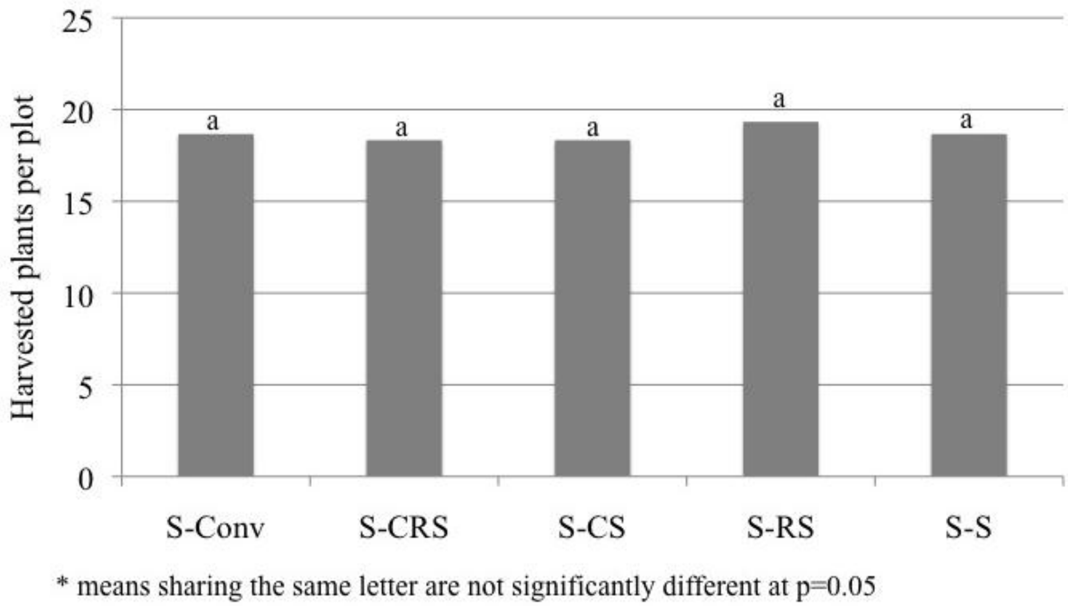


**Figure 23.** Number of plants harvested per plot in soybean chaff residue.

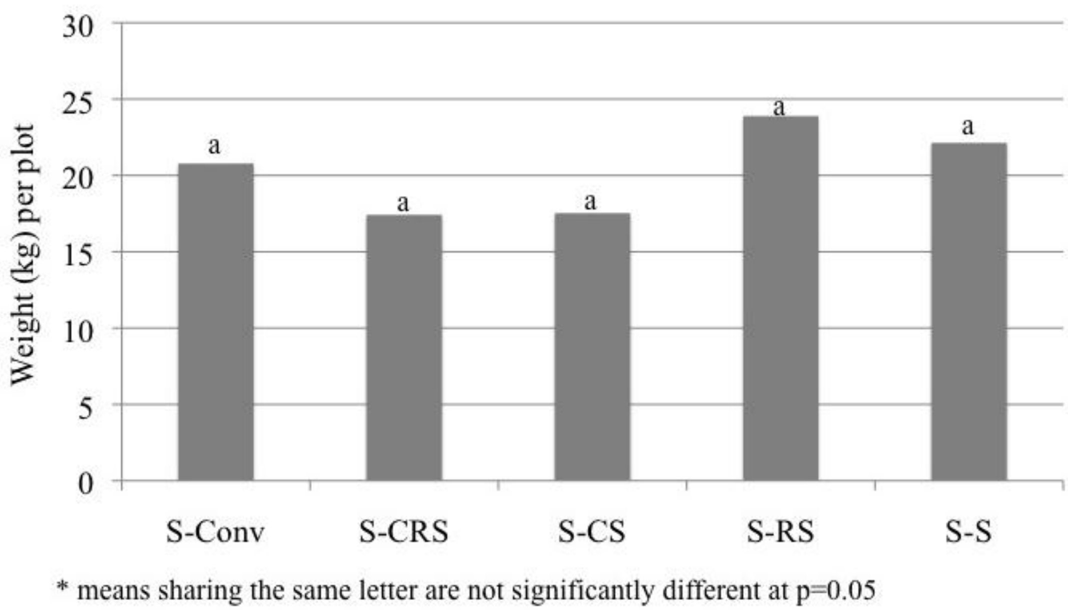


**Figure 24.** Fresh green leaf weight in soybean chaff residue.

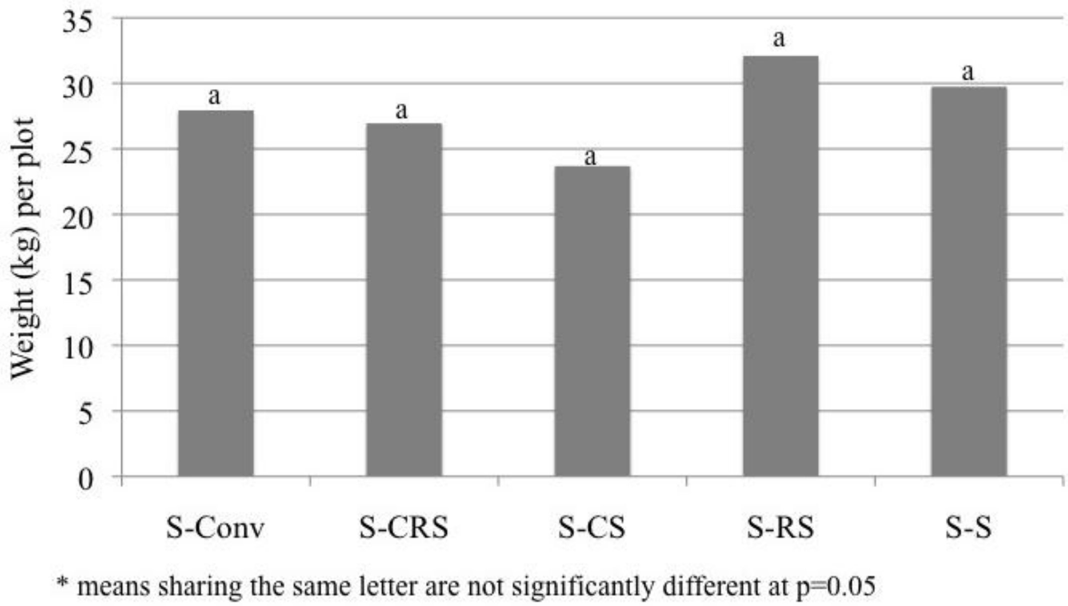


**Figure 25.** Total plant fresh green weight in soybean chaff residue.

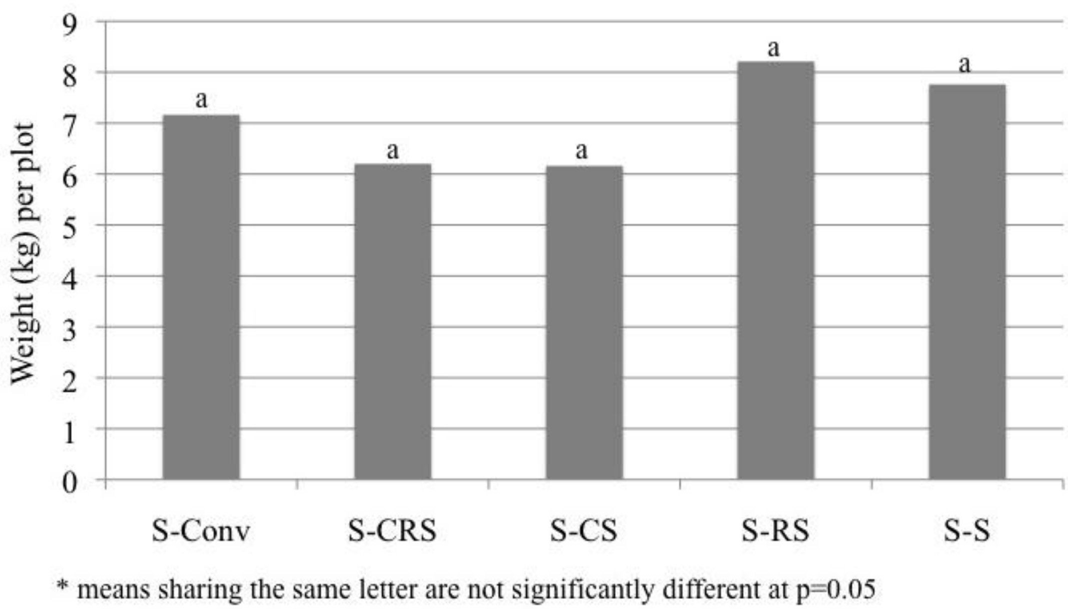


**Figure 26.** Fresh green stalk weight in soybean chaff residue.

There were no differences among any treatment in terms of cured weight per plot (Figure 27) ($P \leq 0.05$). S-RS and S-S showed no difference in cured weight per plot (Figure 28) ($P \leq 0.05$) from S-Conv plots, but did in comparison to S-CS.

S-RS and S-S treatments proved most comparable to S-Conv treatments based on the amount of transplant root exposure and cured weight per plant. The statistically equivalent rate of root exposure may have been due to the lack of the coulter. During transplanting, the transplanter did not seem to penetrate the soil as deeply when the coulter was in place. In treatments where the coulter was detached, specifically S-RS and S-S, soil contact with the double-disc opener was greater, thus improving transplanting.

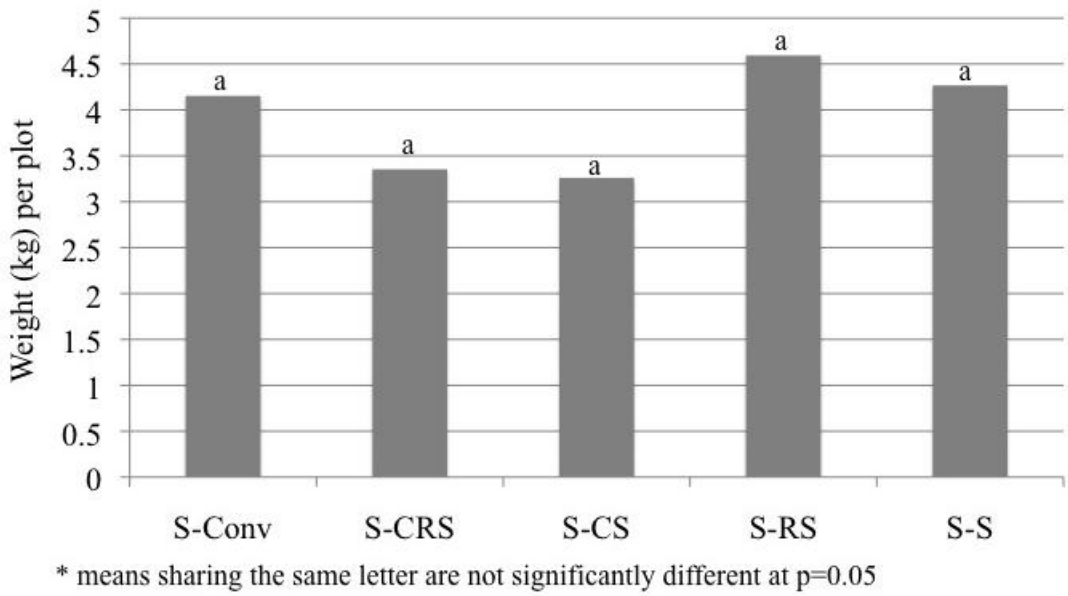


**Figure 27.** Cured weight per plot in soybean chaff residue.

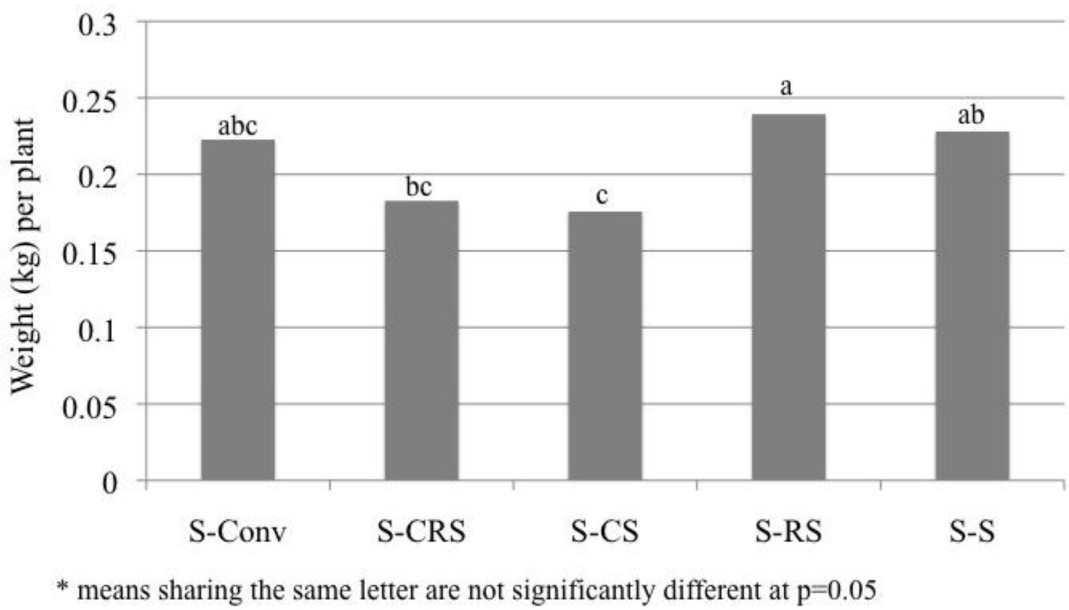


**Figure 28.** Cured weight per plant in soybean chaff residue.

# CHAPTER V

## SUMMARY

Though grown on a small scale in comparison to other types of tobacco as well as other row crops, the importance of soil saving technology in dark tobacco production is a capital issue to address. Implementation of conservation techniques into production methods could drastically influence crop growth in years following tobacco.

No-till technology has enabled farmers to save time, fuel, and labor costs by eliminating unneeded trips over the field to fulfill tillage operations. By saving time spent in the field, both prior to and after transplant, the producer does not have to pay an operator or purchase fuel for the implement. Sufficient weed control can be attained with the proper herbicide regime, consisting of burndown and pre-plant herbicide applications before transplant and sethoxydim application to suppress grass weed growth after transplant, decreasing labor and adding what is to be considered a modest cost when compared to the overall input per acre that is encountered in the production of dark tobacco.

The results of the fescue sod residue trials revealed the F-CRS treatments to be most comparable to conventionally tilled plots based upon the survival rate of transplants (96%), which were similar to the 95% rate of survival in burley trials conducted by Phillips (1989), and cured weight per plot. These treatments also showed the highest numerical amount of residue displaced by the equipment combination, though they were not significantly different than other no-till treatments. This may have influenced the survival rate of transplants in these settings.

S-RS and S-S treatments in the soybean chaff residue exhibited root exposure rates equivalent to those in S-Conv plots.  Conversely to the fescue residue, S-CRS treatments had higher rates of exposure than other treatments in soybean chaff residue. Based upon cured leaf weight per plot, no-till treatments showed no difference from that of S-Conv, supporting the findings of Roach (1981).  Cured leaves per plant were not influenced by treatment but S-RS and S-S treatments had higher numerical, weight per plant than S-Conv plots.

No treatment was equally effective in both residue types.  The influence of equipment combinations seems to have a site-specific relation to both the type of residue cover and the amount of residue present prior to transplant.  Further research and modification could prove viable to the acceptance and expansion of no-till dark tobacco production.

APPENDIX I

List of Modification Materials and Pricing

Frame Extensions: (2)

- Final dimensions:
  - 24” x 17” x 5”
- Material:
  - Rectangular steel tubing
  - 7” x 5” x 3/16”
- 17” components (4)
  - $35.73 each
- 10” components (4)
  - $25.14 each

Frame Extension Reinforcement Plates: (8)

- Size of piece:
  - 3” x 7”
- Material:
  - Flat bar
  - 3” x 3/16”
- $7.23 each

Internal Bolt-In Frame Extension Reinforcement Plates: (4)

- Dimensions:
  - 4” x 17”
- Material:
  - Flat bar
  - 4” x ¼”
- $10.30 each

Row Cleaner Mounting Brackets: (2)

- Base Plate
  - Dimensions:
    - 4” x 8”
  - Material:
    - Flat bar
    - 4” x 3/8”
  - $8.74

- John Deere™ 7000 Coulter Bracket (AA32693)
    - $235.40 each

Row Cleaners: (2)

- Martin™ C125R
    - $414.00 each

Shank Mounts: (2)

- Top and bottom brace plates (4)
    - 5" x 7" x ½"
    - $15.45 each
- Shank attachment plates (4)
    - 15" x 4" x ¼"
    - $9.60 each
- Center Spacer (2)
    - 3" x 3.5" x ¾"
    - $7.45 each

Tillage Shanks: (2)

- Nichols™ N5P8 anhydrous knives
    - $36.00 each

Double-Disc Openers: (2)

- Mechanical Transplanter™ double-disc openers
    - $299.99 each

Weight Brackets: (2)

- 3" x 4" x ½" angled steel
- 3.5" length
- $8.74 each

Pricing information gathered from:
www.discountsteel.com
www.martinandcompany.com
www.greenfarmparts.com
www.mechanicaltransplanter.com
www.orderag.com

## LITERATURE CITED


Akehurst, B. C. *Tobacco.* 2nd ed. (London and Harlow): Longmans, 1981. Print.

Chappell, W. E., and L. A. Link. "Evaluation of Herbicides in No-Tillage Production of Burley Tobacco." *Weed Science* 25.6 (1977): 511-14. Print.

Davis, D. L., and M. T. Nielsen. *Tobacco: Production, Chemistry, and Technology*. Oxford: Blackwell Science, 1999. Print.

Ellis, R. L., G. D. Morgan, G. N. Rhodes, and T. C. Mueller. "Cover Crop Management In No-Till Tobacco." *Tobacco Science* 45 (2001): 44-48. Print.

Garner, W. W. *The Production of Tobacco.* New York, Etc.: Blakiston, 1951. Print.

Hawks, S. N. Jr, and W. K. Collins. "Effects of a Herbicide and Levels of Cultivation on Yield and Value of Flue-Cured Tobacco." *Tobacco Science* 14 (1970): 170-72. Print.

Hillel, D. *Introduction to Soil Physics*. New York: Academic, 1982. Print.

Hoyt, G. D. "The Effects of Tillage Systems on Burley Tobacco Yield and Nitrogen Uptake Patterns." *Tobacco Science* 44 (2000): 1-6. Print.

Huggins, D. R., and J. P. Reganold. "No-Till: The Quiet Revolution." *Scientific American* (2008): 70-77. Print.

Lal, R., and M. Shukla. *Principles of Soil Physics*. New York: M. Dekker, 2004. Print.

Morrison, J. E., D. C. Milbocker, W. O. Atkinson, and J. H. Smiley. "Transplanter Modification and Survival of Transplants under No-Tillage Conditions."*HortScience* 8.6 (1973). Print.

Morse, R. D., D. H. Vaughan, and L. W. Belcher. "Evolution of Conservation Tillage Systems for Transplanted Crops--Potential Role of the Subsurface Tiller Transplanter (SST-T)." (1993): 145-51. Print.

National Agricultural Statistics Service. 2011 Census of Agriculture – United States Data. USDA, 2012.

Pearce, R., and J. Zeleznik. "No-Till Transplanter." www.uky.edu/Ag/**Tobacco**/Pdf/Transplant.pdf. 2003.

Pearce, R., P. Denton, and G. Schwab. "Field Selection, Tillage, and Fertilization." *2011-2012 Kentucky & Tennessee Tobacco Production Guide*. 2012. 24-29. Print. ID-160.

Phillips, R. E., and J. M. Zeleznik. "Production of Burley Tobacco Using No-Tillage and Conventional Tillage." *Journal of Production Agriculture* 2.4 (1989): 343-46. Print.

Roach, S. H. "Reduced- vs. Conventional Tillage in Cotton and Tobacco: A Comparison of Insect Populations and Yields in Northeastern South Carolina, 1977-1979." *Journal of Economic Entomology* 74.6 (1981): 688-95. Print.

Tso, T. C. *Physiology and Biochemistry of Tobacco Plants*. Stroudsburg, PA: Dowden, Hutchinson & Ross, 1972. Print.

Wollenhaupt  Nyle C. and John Pingry. *Estimating Residue Using the Line-Transect Method*. By University of Wisconsin-Extension, 1993. Print. A3533.

Wood, S. D., and A. D. Worsham. "Reducing Soil Erosion in Tobacco Fields with No-Tillage Transplanting." *Journal of Soil and Water Conservation* (1986): 193-96. Print.

Yoder, D. C., T. L. Cope, J. B. Wills, and H. P. Denton. "No-Till Transplanting of Vegetables and Tobacco to Reduce Erosion and Nutrient Surface Runoff." *Journal of Soil and Water Conservation* 60.2 (2005): 68-72. Print.